National Aeronautics and Space Administration

COMMERCIALIZATION, INNOVATION, AND SYNERGIES OFFICE

NASA Leveraging Commercial Communication Ground Stations for Small Satellites

Authors

Organization	Name	Contribution
NASA Goddard Space Flight Center	Scott Schaire	Primary Author /Presenter
	Yen Wong Chitra Patel Leslie Ambrose Obadiah Kegege	Coauthors
University of Alaska, Fairbanks	Denise Thorsen	Coauthor

Exploration & SPACE Communications

Outline

- What the Near Space Network Does
  - Domain of the Near Space Network
  - Current Near Space Network Architecture
- NSN SmallSat/CubeSat Support
  - Emerging Commercial Services (CS) Providers
  - Streamlining the NSN Mission Planning and Integration (MP&I) Function
  - Support CubeSat Transition to NSN Frequencies, Higher Data Rates, and Efficient Modulation/Coding Techniques

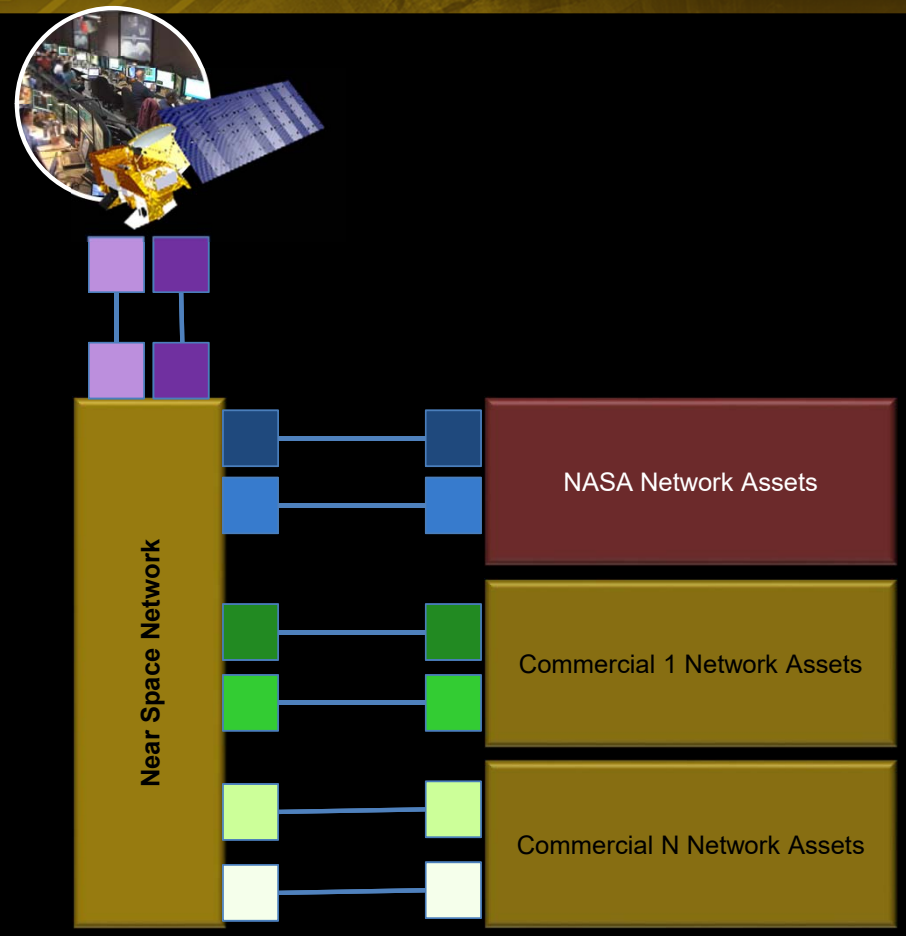
What the Near Space Network (NSN) Does

The Near Space Network empowers diverse missions communications and navigation services.

- We connect customer missions to essential communications and navigation services.
- We alleviate the need for users to do in-depth background research on which services or service providers best fit their mission.

We provide trusted and time-tested expertise to missions as they formulate, design, launch, and operate their missions.

- We utilize government and commercial assets to achieve user goals through the entire mission lifecycle.



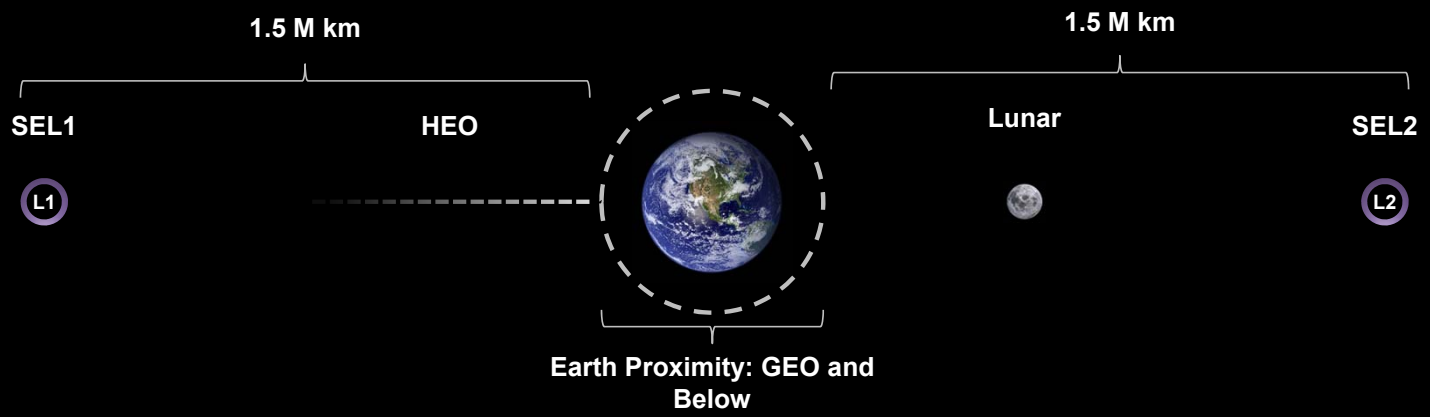
Domain of the Near Space Network (NSN)

Near Space: the volume of space from the Earth's surface to 2,000,000 km

Earth Proximity: a subset of near space; the volume of space from Earth's surface to geosynchronous orbit (36,000 km) and the initial focus of service commercialization

Deep Space: the volume of space starting at 2,000,000 km from Earth's surface and proceeding out into the solar system and beyond. This volume is supported by the Deep Space Network

	FY20	FY25 Projections
Number of Near Space Missions	53 missions	74 missions
Frequency Bands	S, X, Ku, Ka	S, X, Ku, Ka, Optical (Infrared)
Data Rates (DTE, Earth Relay, Lunar Relay)	Up to 3.5 Gbps	>3.5 Gbps



Current Near Space Network (NSN) Infrastructure

NSN SmallSat/CubeSat Support

In addition to larger science missions, the Near Space Network supports the crucial research performed by CubeSats and other small satellites.

The network has a proven track record of success in small satellite support during all phases of the mission lifecycle.

NSN SmallSat/CubeSat Support

Initiative #1: Emerging Commercial Services (CS) Providers

- Continue to identify and evaluate additional viable emerging Commercial Service providers.
- Use of emerging CS providers to provide cost effective alternative for SmallSats while achieving commercialization goals.
- First use of KSAT^{LITE} is planned for the CubeSat Laser Infrared CrosslinK (CLICK) mission
  - The KSAT^{LITE} apertures are typically 3.7-meter, smaller than the typical 11-meter class ground stations in the NSN.
  - In order to accommodate KSAT^{LITE} stations in addition to the NSN-owned stations, the NSN project team needed to analyze terrestrial interfaces, contracting, and NSN Scheduling System (NSNSS) interfaces.

NSN SmallSat/CubeSat Support

Initiative #2: Streamlining the NSN Mission Planning and Integration (MP&I) Function

- Continue to implement efficiencies in NSN mission on-boarding activities.
- CubeSats and SmallSats can be on-boarded in a cost effective streamlined process than the legacy flagship missions.
- Simplifying the documentation/testing to make NSN services more in-line with the CubeSat needs.

NSN Integration and Testing for Reliable Operations (NITRO)

NSN SmallSat Support

Initiative #3: Support CubeSat Transition to NSN Frequencies, Higher Data Rates, and Efficient Modulation/Coding Techniques

- Supports CubeSats with objectives to demo new techniques.
- Provides pathway to traditional missions using new and innovative technology.

LDPC Coding Rate Modulation and Loss	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK Data Rate (Mbps)	4.38	5.23	5.95	6.25	6.98	7.12	7.42	7.51
Implementation Loss (dB)	0.8	1.4	0.5	1.0	1.12	0.62	0.7	0.5
8 PSK Data Rate (Mbps)	-------	7.48	8.12	9.58	10.0	10.4	10.98	11.25
Implementation Loss (dB)	--------	2.5	1.45	0.5	0.6	0.6	0.9	0.8
16 APSK Data Rate (Mbps)	---------	-------	10.81	12.3	12.46	13.86	14.8	15
Implementation Loss (dB)	---------	--------	2.3	1.8	1.2	0.8	0.8	1.0
Note: Additional BER test for 32 APSK 9/10 achieved 16.23 Mbps with approximately 1 dB implementation loss.								

Digital Video Broadcast Satellite Second Generation (DVB-S2) Measured Data Rates (Mbps) and Implementation Loss Performance for NSN S-band 5 MHz Channel

DVB-S2 Advantages for X-band

Mod/Coding Rate	1/4	1/3	2/5	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK	147	170	236.7	296.6	356.5	396.6	446.2	476.16	496.4	530	536.4
8 PSK					534	594	668.4	N/A	743.4	793.8	803.7
16 PSK						791	890	950	990	1057	1070
32 PSK							1111	1185.5	1235.7	1319	1336

DVB-S2 Predicted Maximum Data Rate (Mbps) in NSN X-band 375 MHz AWGN Channel

DVB-S2 Advantages for Ka-band

Mod/Coding Rate	1/4	1/3	2/5	1/2	3/5	2/3	3/4	4/5	5/6	8/9	9/10
QPSK	245	328	394.7	494.4	594.5	661	743.7	793.5	827.3	883.3	894.3
8 PSK					890	990	1114	N/A	1239	1323	1340
16 PSK						1318.5	1483	1582.8	1650	1761.5	1783.5
32 PSK							1850	1975.8	2059.5	2219	2226

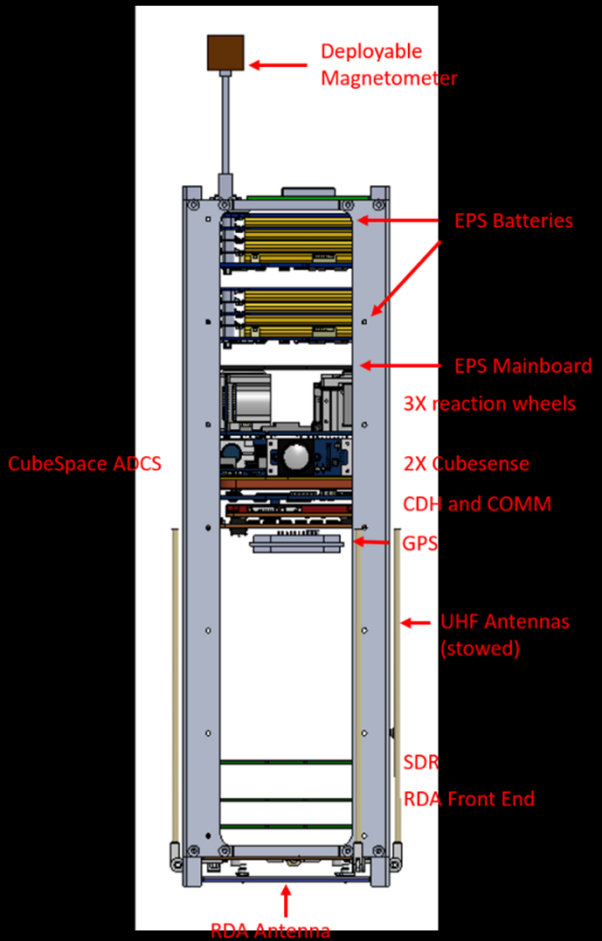
DVB-S2 Predicted Maximum Data Rate (Mbps) in NSN Ka-band 1.5 GHz AWGN Channel

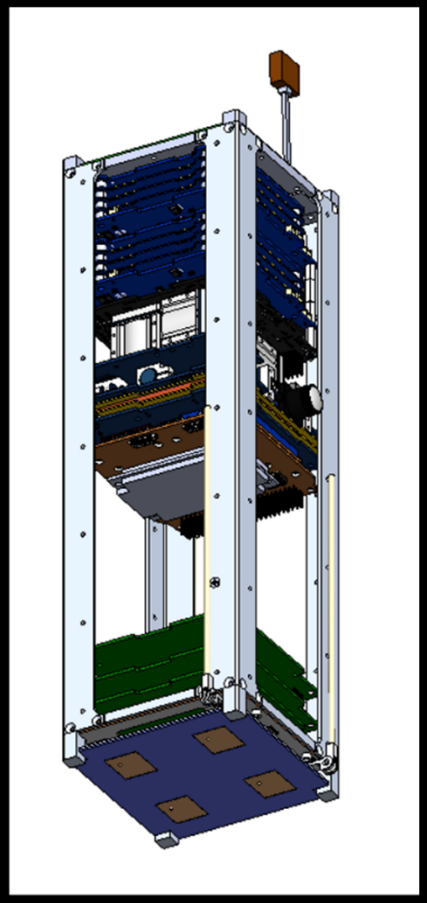
Selected CubeSat/SmallSat DVB-S2 Radios

Radio	Frequency Range	RF Power	Data Rate	CCSCS DVB-S2 Compliance
EnduroSat S-band Transmitter	2200-2290 MHz	2 W	20 Mbps	Yes
EnduroSat X-band Transmitter	8250-8400 MHz	2 W	150 Mbps	Yes
Augustus Aerospace S2DR HRTX S-band Transmitter	2200-2300 MHz	1 W	60 Msps	Yes
Augustus Aerospace S2DR HRTX X-band Transmitter	8025-8400 MHz	1 W	60 Msps	Yes
Syrlinks X-band Transmitter	8025-8400 MHz	1to 3 W	122 to 149 Mbps	Yes
GOMSPACE NanoCom XT8250 X-band Transmitter	8000-8500 MHz	3 W	225 Mbps	Yes
SNT SAIT X-band Transmitter	8100-8500 MHz	2.5 W	250 Msps	Yes
Astro Digital Transmitter	25.5-27.0 GHz	0.6 W	34 to 320 Mbps	Yes

CubeSat Communications Platform (CCP)

Miniaturized S-band active phased array (SPA) and a Software Defined Radio (SDR) utilizing variable coded modulation (VCM).

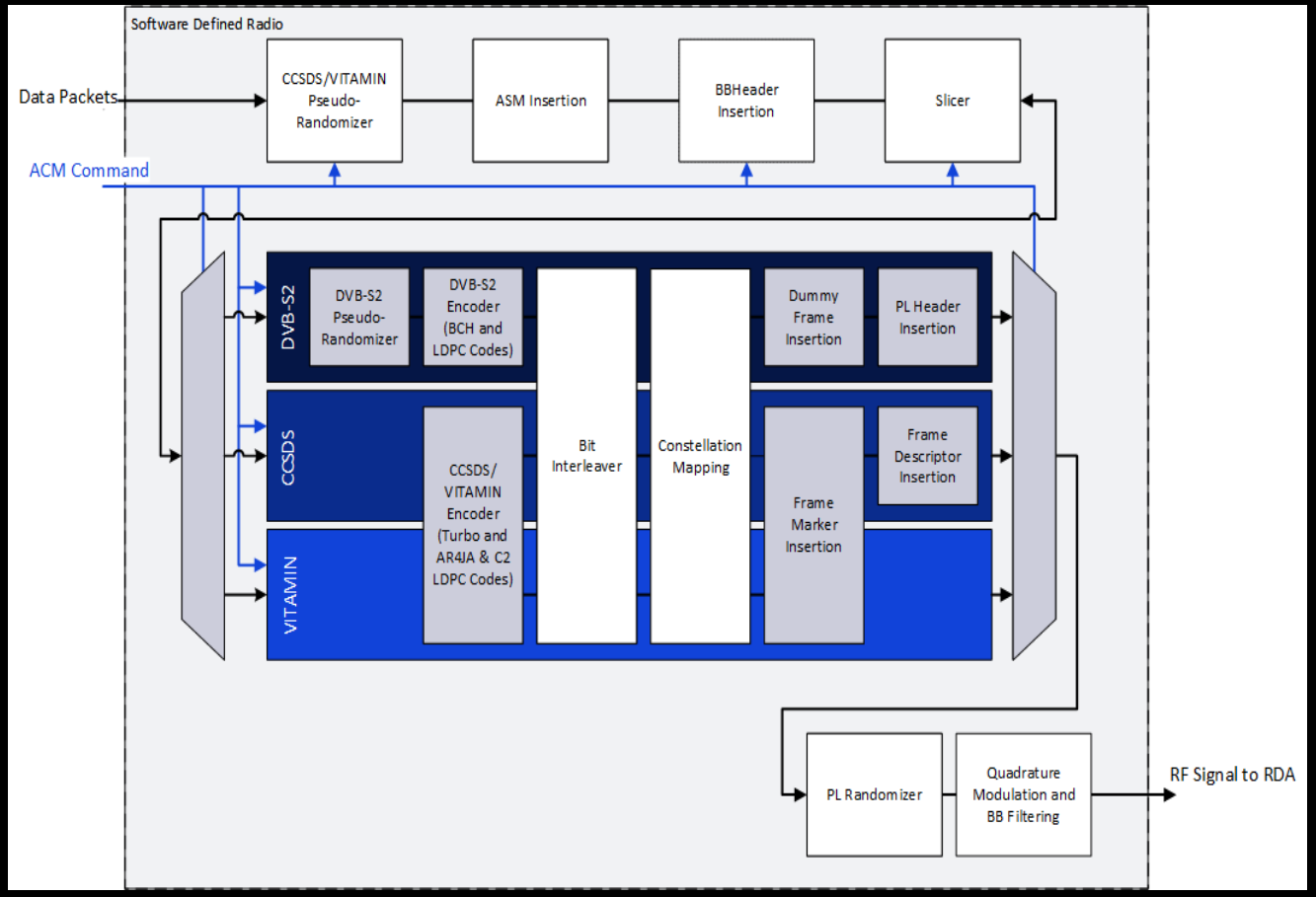




VITAMIN (Variable-Coded Modulation to maximize information) will use a high bit rate modulation and coding when the signal-to-noise ratio (SNR) is strong. When the SNR is weak, the SDR will use a low bit rate modulation and coding to maintain link margin.

CCP Functional Blocks for VCM Protocols

Designed to answer the question of how to maximize the information downlinked from a CubeSat.



Spacecraft mission includes various attitude control modes (nadir, limb, random tumble) during ground station passes.

Thanks for listening

- ✓ NASA's NSN is excited to offer to the NASA small satellite community evolving commercial services with technologies such as DVB-S2.
- ✓ DVB-S2 will increase science data return for all missions and enable support for a greater number of CubeSats/SmallSats at high data rates.
- ✓ The NSN is actively seeking additional flight and ground solutions for evaluation and welcomes contact for technical discussions.

For more information about Near Space Network contact:

Scott Schaire: scott.h.schaire@nasa.gov

Obadiah Kegege: obadiah.kegege@nasa.gov

New Missions

gsfc-missiononboarding@mail.nasa.gov

SCAN ME

ESC

Exploration and Space Communications

SCAN ME